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THE GROWTH-PROMOTING PROPERTIES OF FOODS DERIVED FROM CORN AND WHEAT.

By CARL VOEGTLIN and C. N. MYERS, Division of Pharmacology, Hygienic Laboratory, United States Public Health Service.

The authors in a preceding paper have shown that the whole wheat or corn grain contains an abundance of antineuritic vitamine, whereas the "highly milled" products derived from these cereals are deficient in this respect. This conclusion was drawn from experiments on adult animals. As growing animals require the presence of all dietary constituents to a greater extent than do adults, it seemed desirable to continue the investigation along this line. Recent studies on growth have furnished the necessary information to answer the question as to what constitutes a diet complete enough to insure growth. It is now generally held that a physiologically sufficient diet must contain an adequate caloric value derived from protein of proper composition, carbohydrate, and fat. In addition it must contain a sufficient amount of antineuritic and fat-soluble vitamines and of necessary inorganic salts.

The dietary deficiencies of the whole wheat and corn kernel in the diet of growing animals have already been investigated. Thus Hart and McCollum (1914), working with young albino rats and hogs, have shown that normal growth is obtained when the wheat kernel is supplemented by the addition of inorganic salts, fat-soluble vitamine, and casein. Subnormal growth was observed with rations consisting of wheat plus casein and salts; wheat plus casein and butter fat; wheat plus salts and butter fat.

McCollum, Simmonds, and Pitz (1916) have made similar observations with corn. In this case also the grain requires an improvement in its protein moiety, its salt content, and an added supply of fat-soluble vitamine. Of these three additions the correction of the deficiency in certain inorganic salts seemed to be of the greatest importance, inasmuch as this correction in itself furnished a ration on which rats did grow fairly well for several months.

Hart, Halpin, and Steenbock (1917) report experiments with pullets weighing 2 to 3 pounds on corn and wheat rations These investigators found that corn and wheat meal do not support growth in this species of animals; fortifying the cereals with an appropriate

inorganic salt mixture, protein of proper composition, and a small amount of fat-soluble vitamine (2 per cent butter fat) leads to normal growth. These authors also call attention to the possibility of intoxication as a result of excessive wheat feeding, which they attribute to the presence of some toxic substance in the wheat kernel.

The purpose of the present investigation was to answer the question as to whether the corn and wheat products used in human nutrition exhibit similar dietary deficiencies as those of the whole grains. The bulk of the corn and wheat foods of the American dietary are derived from the wheat and corn kernel by means of a process of milling (roller mills) which is known to eliminate most of the germ and superficial layers of the grain. It, therefore, seemed to us a question of practical importance to determine whether the milling process improves, or causes a decrease in, the dietary value of the milled product. Moreover, it was desirable to decide whether or not the food additions made to flour (yeast, salt, milk) in the preparation of bread improve the nutritive value of this food.

Experimental.

The experiments were carried out on squabs, young albino mice, and a few hogs. Most of the work was done with wheat, and only a few incomplete experiments were made with foods obtained from corn.

We are not aware of any previous records where squabs have been used for studies on growth. For this reason the following details are given, as they may be of interest to workers in this field. The growth period of pigeons is extremely short, as will be seen from the records. Almost maximum body weight is reached, on an adequate diet, within 40 days after the squabs are hatched. The feathers develop gradually, and by the time full growth is reached the body is completely covered. The birds begin to fly at the age of about 40 days. This is usually followed by a slight loss of body weight, which is probably due to the strenuous muscular work performed in flying. It should be pointed out that squabs can not feed themselves during the first two weeks of life. During this period the parents feed the young by regurgitating food which has been softened in their crops. The function of the crop consists in the preparation of the cereal food for gastric digestion. It is very doubtful whether active digestion takes place within the crop, and it is more likely that this organ simply softens the food by means of water in order to facilitate its disintegration by the stomach. In the absence of the crop, gastric digestion of cereals would be a rather slow process, even in the case of the bird's stomach with its powerful muscular wall and the gravel which takes the place of millstones.

In order to obtain a sufficient number of squabs for experiments on growth, about 70 to 100 healthy pigeons were kept in a well-ventilated room containing numerous cages (wire screened), the doors of which were left open. Usually the birds built their nests in these cages and after laying the eggs the parents were caught, confined to the cage, and put on the diet to be tested for its growth-promoting properties. When it happened that eggs were laid outside of the cages, the pigeons were allowed to hatch and the young squabs were then transferred, with the nest and the parent birds, to the nearest cage. We found that it was impossible to move the eggs, as the birds refused to sit after the eggs had been handled. The sitting period of pigeons is about 17 days. The male bird sits from about 9 a. m. to 5 p. m.; the female from 5 p. m. to 9 a. m.

The stock pigeons were fed for nearly two years, while this work was in progress, on an exclusive diet of corn and wheat, crushed oyster shells, and river sand. Fresh running water was supplied. On this diet the birds bred very well throughout the year, with the exception of the moulting season.

The average egg weighed about 16 grams; the contents, minus the shell, weighed about 15 grams, and the weight of the squab immediately after hatching was about 13 grams. It was found that squabs which were below the average body weight and those that had difficulty in hatching, were of low vitality. The squabs were weighed as soon after hatching as possible and every three days thereafter during the morning hours (9 a. m.). The growth curve during the first 10 days is almost a straight line, slight deviations being due to variations of crop content. The birds which died as a result of a diet of inadequate composition were necropsied and the sciatic nerves examined for the presence of myelin degeneration.

The great advantage of using squabs for growth experiments is due to the possibility of immediately starting the newborn animal on a ration which is to be investigated. It is obvious that this can not be done when mammals are used.

The experiments with albino mice were carried out on young animals weighing approximately 6 to 8 grams and obtained from a healthy stock kept in the laboratory. Recent work has sufficiently demonstrated that mice are as well suited for growth experiments as albino rats. The animals were placed in wide glass jars with a wire screened top. Sawdust was used as bedding. Under these conditions the mice could be kept in excellent health on an adequate diet for nearly a year. The animals were weighed every three or four days.[1]

The hogs used were young animals, either purchased on the open market or raised in the laboratory. They were kept in stalls with a concrete floor. The bedding was wheat straw, some of which was eaten by the animals. Tap water was supplied. The experiments on hogs are somewhat complicated, as the straw and tap water may perhaps be considered as a source of inorganic salts and fat-soluble vitamine. However, this factor remained approximately constant in each experiment.

Food used.—When the whole wheat was fed to mice it was usually crushed in an ordinary kitchen mill. The wheat flour, either alone or with other foods, was made into cakes by means of water. The wet cakes were dried at 45° C. and broken up into small pieces. The white flour used was bought under the name of "patent" flour and came from one of the largest roller mills of the West. The wheat "middlings" were obtained from a roller mill in Washington, D. C. The "whole wheat" bread used was purchased in Washington, D. C., and the bakery volunteered the following information in regard to the food materials used in the preparation of this bread: Standard loaves were made from crushed whole wheat, with the addition of canned eggs, some salt, olive oil, molasses, compound lard, wheat bran, and pressed yeast. The accurate proportions of the various constitutents could not be obtained. The "white" bread was made from "highly milled" wheat flour, with the addition of sodium chloride, compound lard, yeast, and evaporated milk. For 900 standard loaves of this bread, 588 pounds of flour, 47 pounds of evaporated milk, and 8¾ pounds of pressed yeast were used.

In the experiments where the "white" bread was supplemented by other foods, the bread was first dried at 40 to 50° C., crushed in a mill, and mixed with the other food in the desired proportions. The casein was a purified preparation made in this laboratory. The crushed oyster shells, fed to the pigeons, consisted largely of calcium carbonate, with traces of organic matter. When the rations contained chemically pure calcium carbonate in place of the oyster shells, exactly the same results were obtained so far as the growth of squabs was concerned. The grit was

[1] The normal growth curve of mice was taken from the article by Mitchell, J., Biol. Chem., 1916, vol. 26, p. 24.

well-washed river sand, consisting mainly of silicates. The so-called "activated" Lloyd's reagent was used as a source of antineuritic vitamine.[1]

In some experiments the "inactive" Lloyd's reagent was included in the rations. Fuller's earth, which had not been in contact with the yeast filtrate, was used in this case. The highest proportion of activated Lloyd's reagent contained in any of the rations was 3 per cent. In most cases 0.6 per cent or 1.5 per cent were used with equal success. When the activated Lloyd's reagent forms 0.6 or 1.5 per cent of the ration, the total nitrogen derived from this source represents only 15 to 37 milligrams.

It should be pointed out that squabs do not well tolerate the addition of considerable quantities of fat to the diet. In some experiments, where 5 per cent of lard was incorporated in the ration, the birds showed diarrhea and poor growth, followed by decline and death.

Summary.

It seems superfluous to enter into a detailed discussion of the results obtained in this investigation, as the accompanying charts illustrate the results in a comprehensive manner. For this reason only the main points will be referred to in this summary.

1. The "highly milled" products are, without exception, inferior in dietary value, as regards growth, to foods prepared from the whole grain. It is rather surprising that such delicate organs as the gastro-intestinal tract of young mice can tolerate a diet containing a large amount of bran. This fact, however, does not necessarily mean that it is advantageous to include the bran in foods intended for human nutrition. On the contrary, the experiences with "war bread" would rather indicate that persons with delicate digestion are subject to temporary digestive disturbances as a result of a change from "white" bread to bread containing a considerable percentage of bran ("war bread"). On the other hand, from the standpoint of dietary completeness, a bread including all of the grain, with the exception of the superficial cellulose layer, is undoubtedly superior to the so-called white bread, made from "highly milled" flour, and would not possess the above-mentioned objectionable features.

2. The "white" bread used in these experiments was not adequate for maintaining normal growth, in spite of the fact that it was prepared with some evaporated milk and yeast. The most significant defect of "white" flour is the deficiency in antineuritic and fat-soluble vitamine; it is also deficient in adequate protein and inorganic salts.

3. A wheat flour, containing a considerable part of the germ and superficial layers of the grain, supports growth of mice and pigeons especially well when supplemented with inorganic salts. The same is true of "whole wheat" bread.

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[1] It was prepared from autolyzed brewer's yeast by treatment with hydrochloric acid and filtration. This yeast filtrate was then treated with a special grade of fuller's earth, which removed a considerable part of the active vitamine from the yeast filtrate. The dried preparation was free of protein and gave negative tests for tryptophan, cystin, and tyrosin. No lysin could be isolated but the activated Llloyd's reagent contained a substance which in its reactions resembled histidine. The total nitrogen content of the dried reagent was about 2.5 per cent, and this consisted largely of adenine and other basic substances derived from yeast filtrate.

4. "Highly milled" corn grits, forming the exclusive food of young hogs, leads to failure of growth in these animals, whereas the whole corn kernel, supplemented by inorganic salts, promotes growth.

5. Newborn squabs are suitable animals for growth experiments.

6. No evidence of a toxic action of a whole wheat diet was obtained in the experiments on squabs which were fed on whole wheat meal, supplemented by a suitable salt mixture.

7. In the light of our present knowledge, it would appear that bread made from "whole wheat" flour, or old-fashioned corn meal, should be used in preference to "white" bread and "highly milled" corn foods, whenever the diet is restricted to these cereal foods to the more or less complete exclusion of other foods possessing greater dietary values.

Bibliography.

Hart, Halpin, and Steenbock. 1917. J. Biol. Chem., vol. 31, p. 415.
Hart and McCollum. 1914. J. Biol. Chem., vol. 19, p. 373.
McCollum, Simmonds, and Pitz. 1916. J. Biol. Chem., vol. 28, p. 153.
Mitchell. 1916. J. Biol. Chem., vol. 26, p. 24.

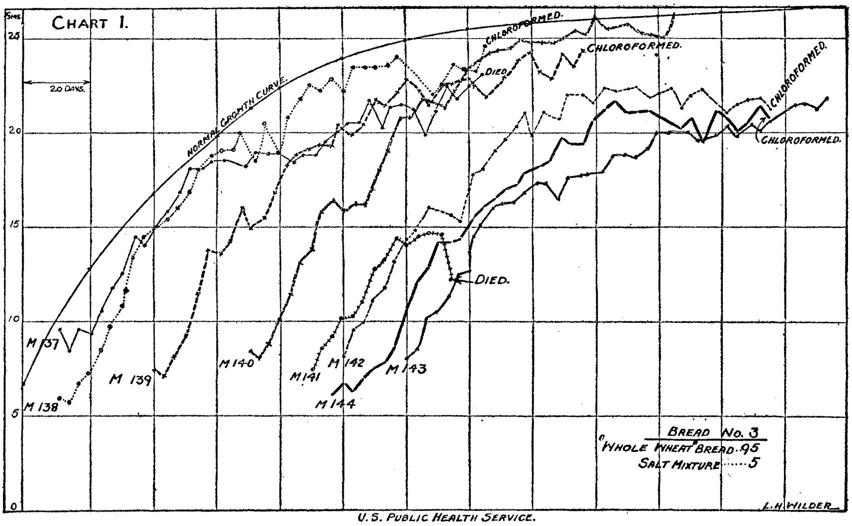

CHART 1.—Shows satisfactory growth of mice when "whole wheat" bread is supplemented with 5 per cent of salt mixture. Evidently the whole wheat bread used in this experiment was slightly deficient in inorganic salts, as seen from chart 2, where the bread was fed without the addition of the salt mixture. The composition of the salt mixture used in this investigation was as follows: NaCl, 0.50 gm.; K_2HPO_4, 1.21 gm.; $CaH_4(Po_4)$, H_2O, 0.256 gm.; Calcium lactate, 2.944 gm.; Ferric citrate, 0.100 gm.

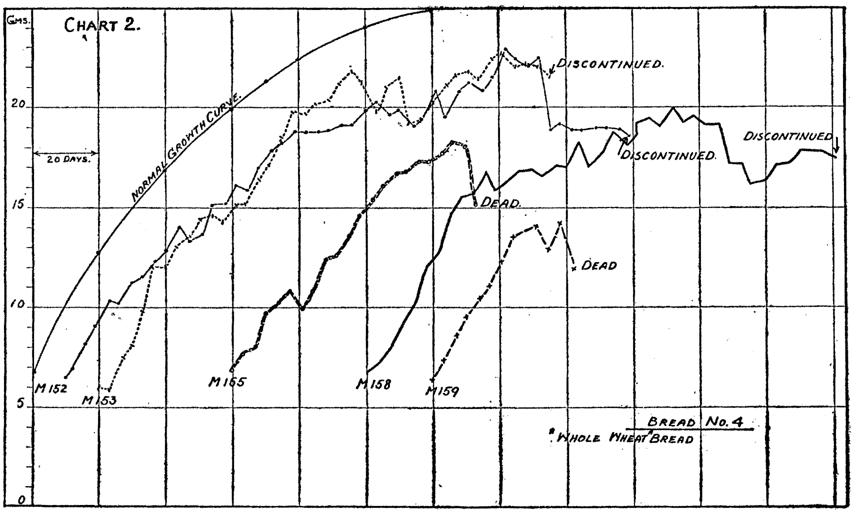

CHART 2.—Illustrates the growth of mice on "whole wheat" bread. The retardation of growth is mainly due to the deficiency of this diet in inorganic salts. (See chart 1.)

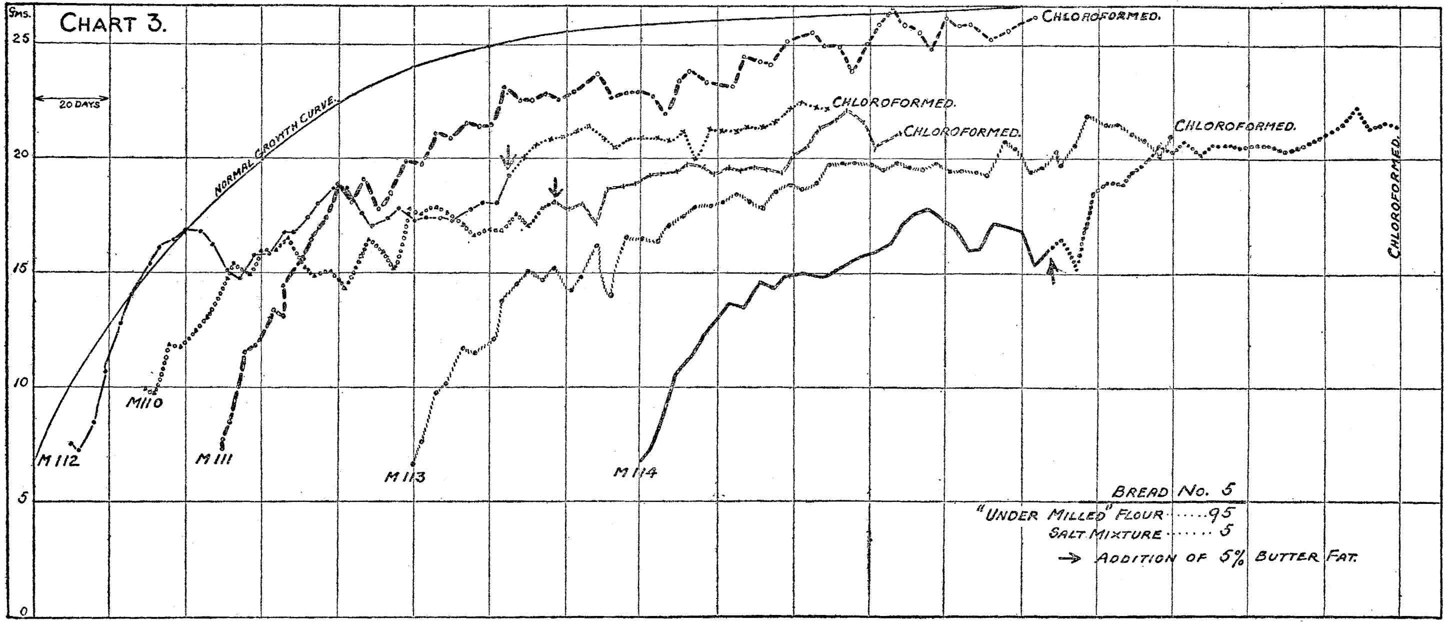

CHART 3.—Growth of mice. Shows beneficial effect of the addition of salt mixture to "undermilled" flour (compare with chart 4). Addition of 5 per cent butterfat to the diet (as indicated by arrows) increased rate of growth of mouse 114, but not of mice 110 and 112. From charts 3 and 4 it seems that this "undermilled" flour is deficient in certain inorganic salts and possibly fat soluble vitamine.

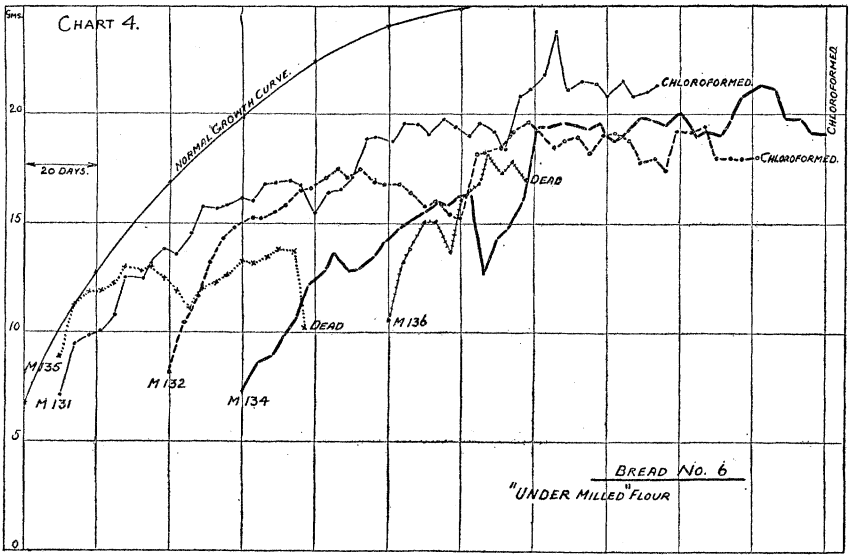

CHART 4.—Illustrates the subnormal growth of mice on a diet of "under milled" flour. This flour was obtained from a roller mill and was bought as "second clear." It contained 0.92 per cent P_2O_5. From the phosphorous content of this flour it would appear that this product is the grade of flour intermediate between a "first and second clear."

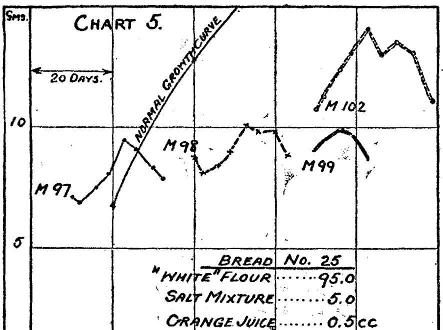

CHART 5.—Shows insignificant growth of mice when "white" flour is supplemented with a salt mixture. The orange juice was added to the drinking water with the idea of preventing scorbutic symptoms. The "white" flour was bought under the name of "patent" flour and contained 0.25 per cent of P_2O_5. The sciatic nerves of mouse 102, 96, and 97 showed marked myelin degeneration. These animals probably died of polyneuritis.

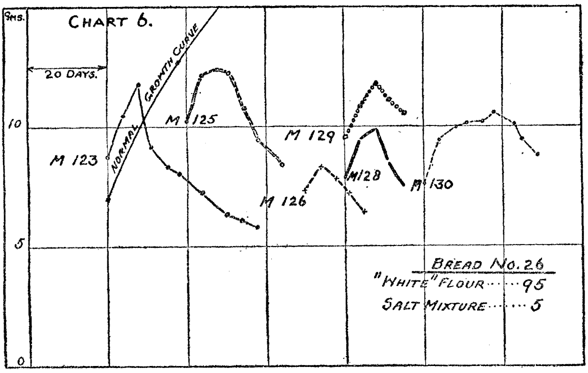

CHART 6.—Illustrates early failure of growth, followed by death of mice on a diet of "white" flour plus salt mixture. The sciatic nerves of these mice showed marked myelin degeneration. The results of this experiment are therefore identical with the one which is illustrated by chart 5.

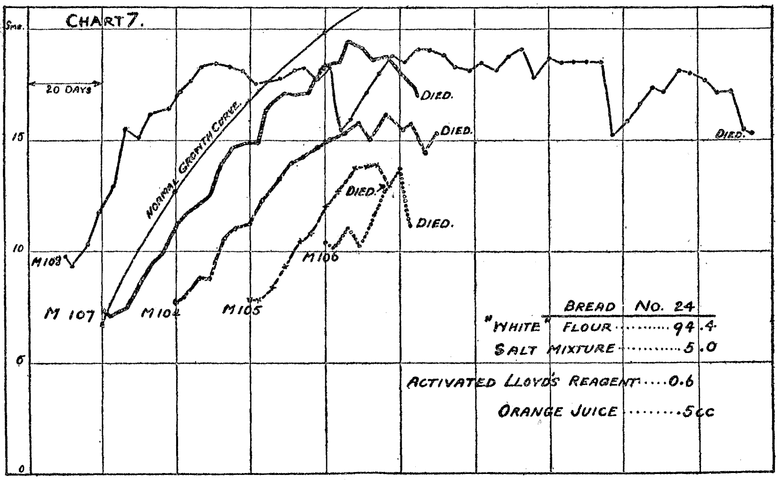

CHART 7.—Growth of mice. Illustrates beneficial effect of the addition of antineuritic vitamine in the form of activated Lloyd's reagent to a mixture of "white" flour and inorganic salts. Compare with charts 5 and 6. Bread No. 24 is not a complete diet, probably deficient in fat-soluble vitamine and certain essential amino acids.

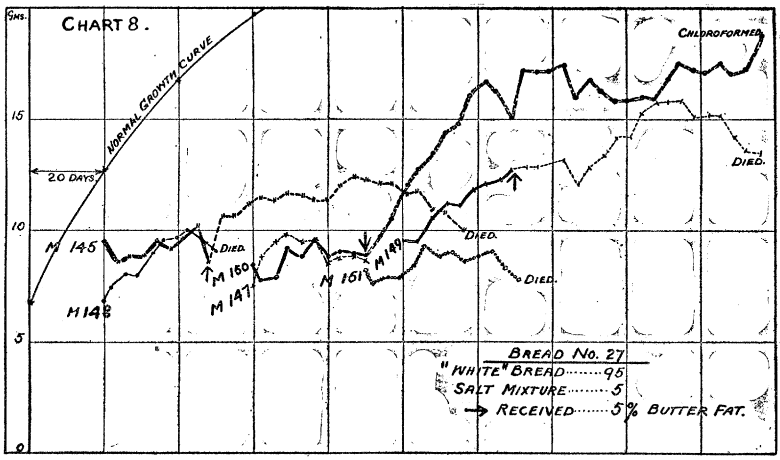

CHART 8.—Practically no growth (except in mouse 149) was obtained on a diet of "white" bread and salt mixture. The addition of 5 per cent butter fat (as indicated by arrows) caused considerable growth in mouse 150. Mice 145 and 149 showed somewhat better growth as a result of the butter-fat addition, but both animals died later on in the experiment. The sciatic nerve of one animal of this group and which was examined after death showed considerable myelin degeneration. (Indication that this diet is deficient in antineuritic substance.)

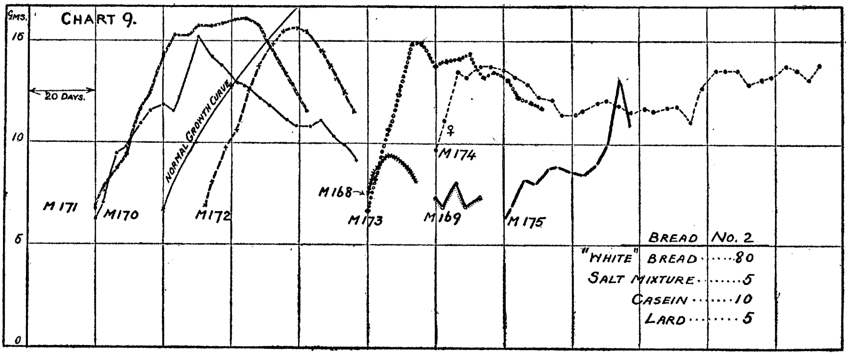

CHART 9.—Shows beneficial effect on growth of mice as a result of the addition of casein and lard to bread No. 27 (see chart 8). All of the animals died, however, with the exception of mouse 174. The "white" bread is evidently deficient in antineuritic vitamine and amino acids, essential for normal growth. Bread No. 2 is also deficient in antineuritic vitamine (compare with chart 11). Bread No. 2 is same as bread 27, except that the former is supplemented by casein and lard.

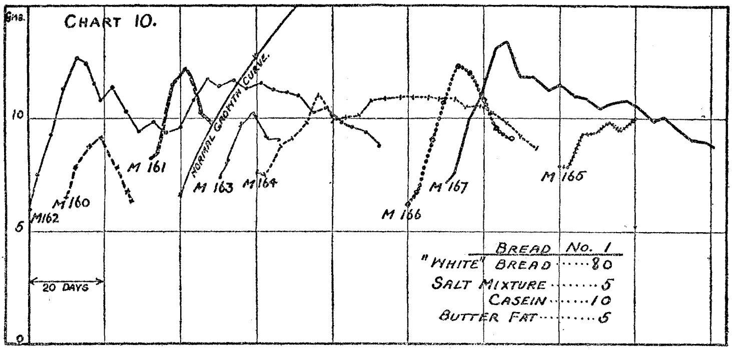

CHART 10.—Illustrates deficiency of bread No. 1 in antineuritic vitamine. Compare with chart 12. All the mice of this series died after periods ranging from 16 to 93 days.

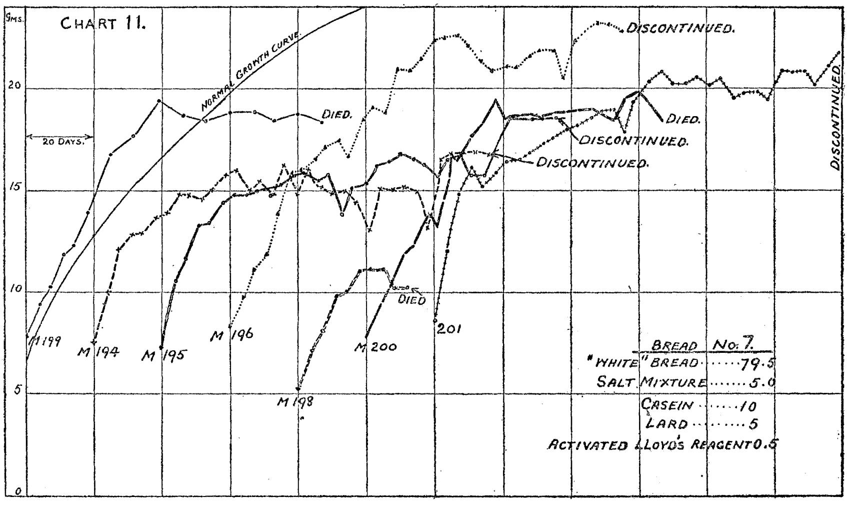

CHART 11.—Bread No. 7, which is deficient in fat-soluble vitamine, leads to fairly good growth in mice. Mice 196 and 201 showed normal growth for a considerable length of time (120 days) and reached nearly maximum weight. The other mice of this series stopped growing after having been on this diet for 40 days.

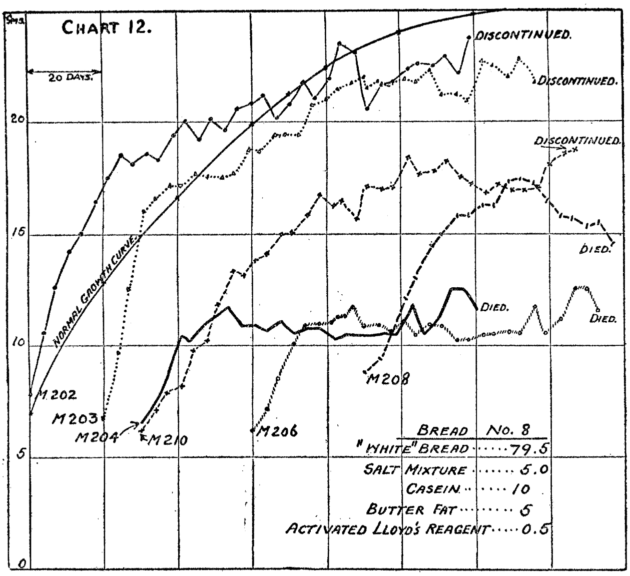

CHART 12.—Illustrates the fairly good growth of mice on bread No. 8. Completion of growth was not obtained with all the mice of this series. Mice 204 and 206 did not grow well after having reached about 12 gm. of body weight.

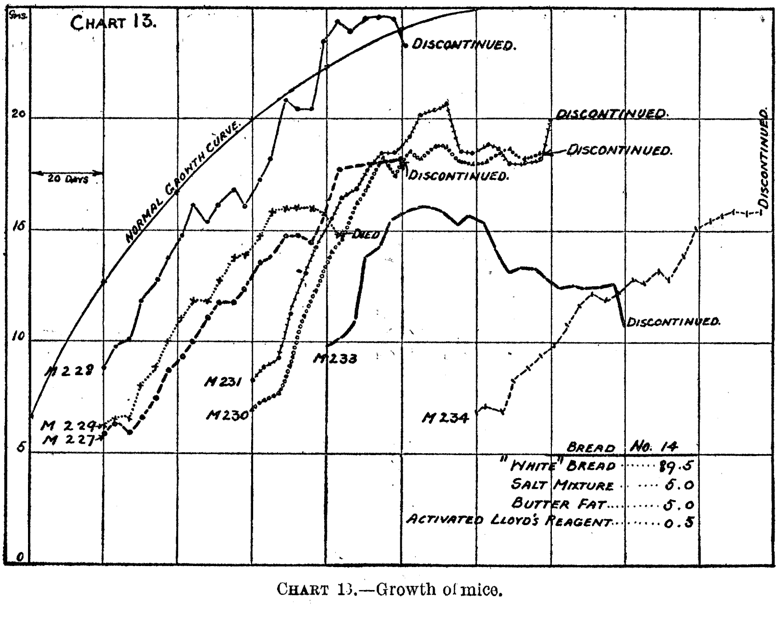

CHART 13.—Growth of mice.

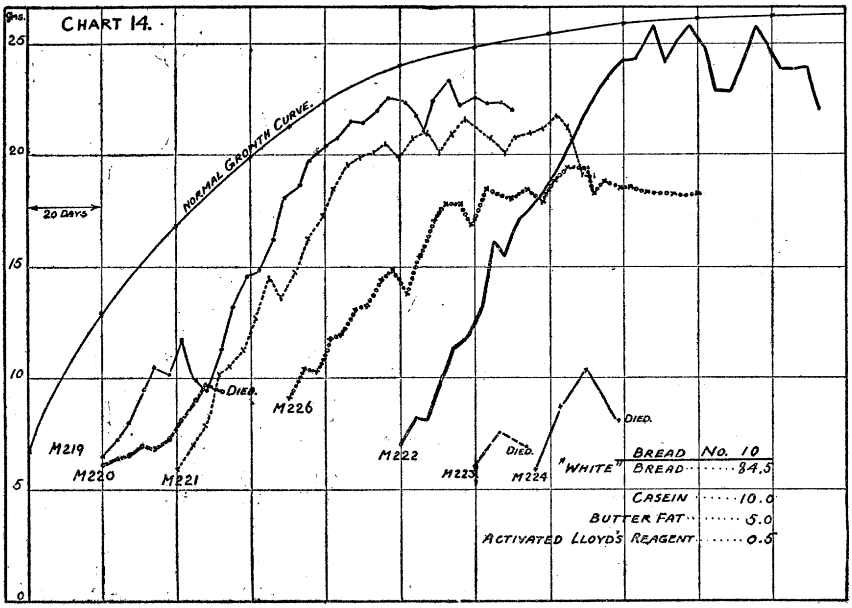

CHART 14.—Shows retardation of growth of mice on bread No. 10, deficient in inorganic salts.

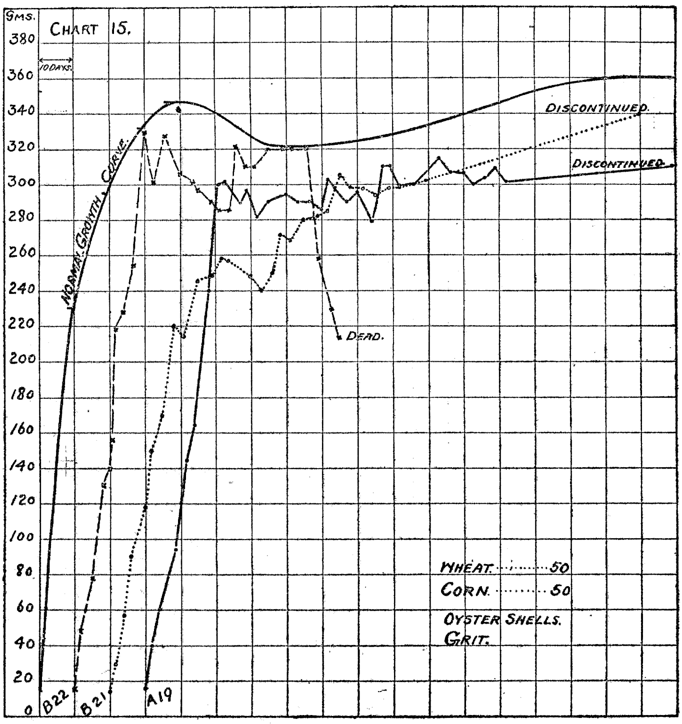

CHART 15.—Shows satisfactory growth of squabs on a diet limited to the corn and wheat kernel, supplemented by the addition of calcium carbonate (oyster shells). The oyster shells were crushed and fed to the parents ad libitum. Squab B22 reached normal body weight in 20 days, but died suddenly at the age of 75 days. The cause of death is unknown. The other two squabs of this series showed normal growth and development and lived for 150 days, when the experiment was discontinued. The appearance of the birds at this time was normal in every respect.

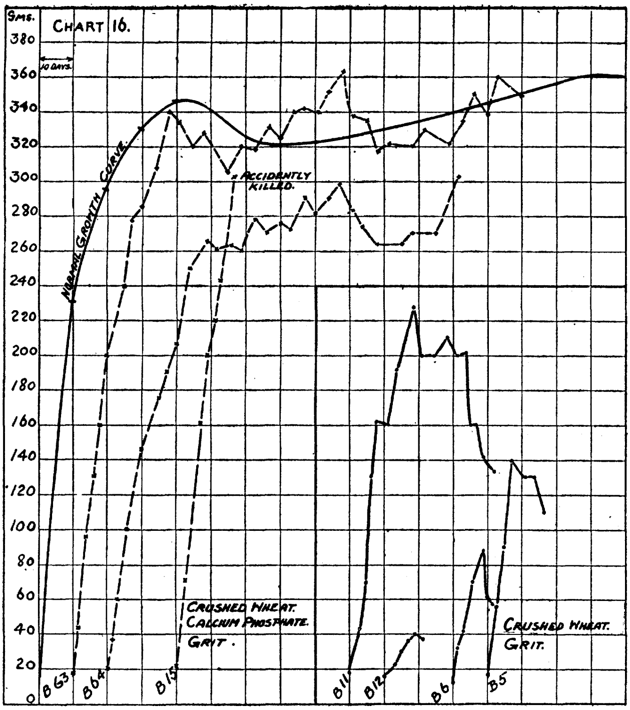

CHART 16.—Shows failure of growth of squabs on a diet of whole wheat alone. The birds evidently suffered from privation of mineral salts. The skeleton was poorly developed, calcification being very deficient. When the wheat kernel was supplemented by the addition of calcium phosphate practically normal growth was obtained. Sciatic nerve of Squab B11, B5, and B6 shows no myelin degeneration.

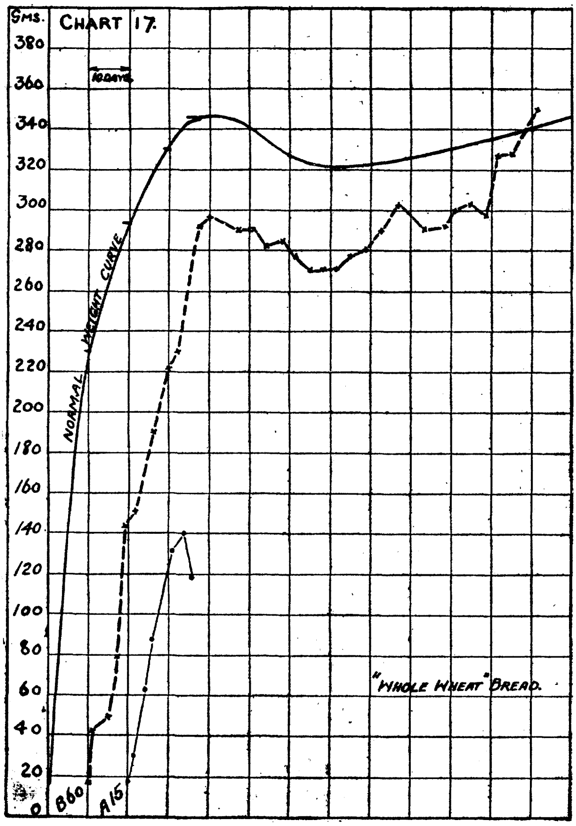

CHART 17.—Shows delayed growth and failure of growth of squabs on "whole wheat bread." This food is deficient in calcium salts. Compare with chart 18. Sciatic nerve of squab A15 did not reveal any myelin degeneration.

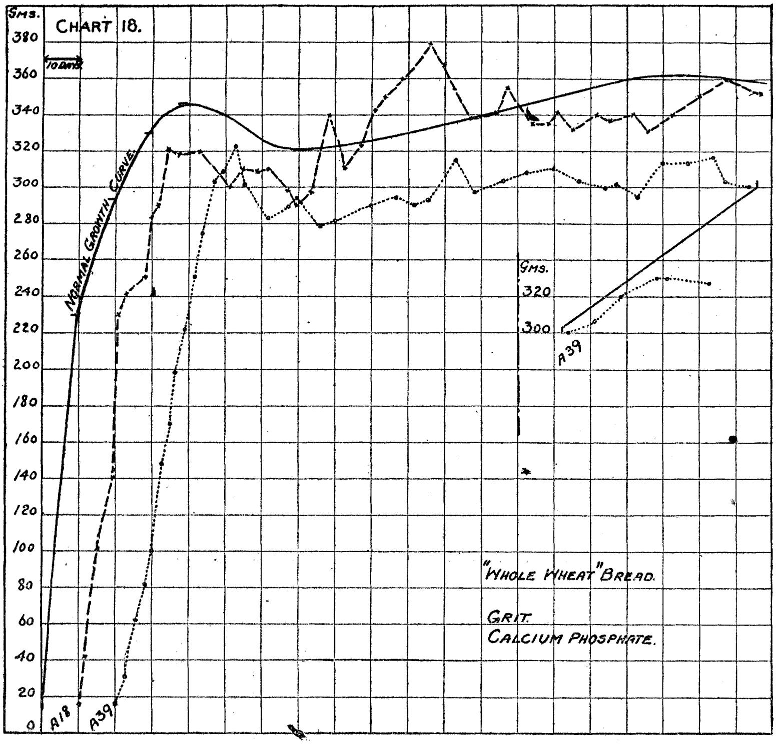

CHART 18.—Illustrates normal growth and development of squabs on a diet of "whole wheat" bread and calcium phosphate. The parents of these two squabs raised two other pairs of squabs while being fed on this diet. This proves that growth, reproduction, and maintenance of normal nutrition are possible on a simple diet as "whole wheat" bread supplemented by calcium salts.

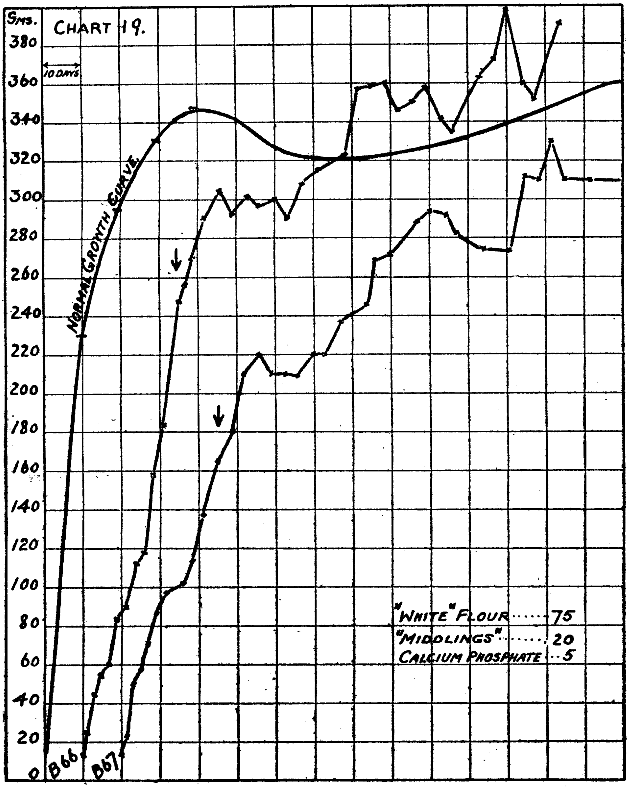

CHART 19.—Growth of squabs. Shows beneficial effect of addition of "middlings" and calcium phosphate to "highly milled" flour. The "middlings" fed with the mixture for the first 25 days of the experiment had the appearance of wheat bran and contained 1.88 per cent P_2O_5. The mixture of "white" flour and "middlings" contained 1.21 per cent P_2O_5. Compare this chart with chart 28.

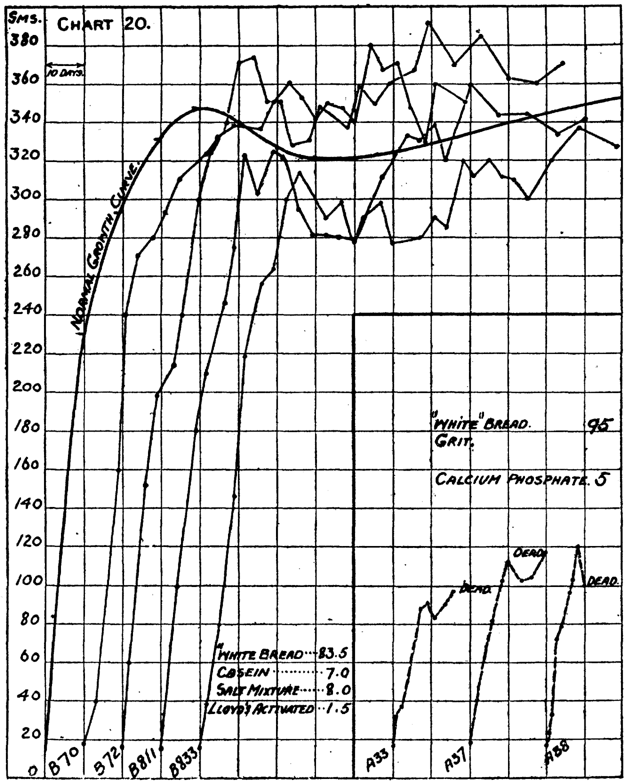

CHART 20.—Illustrates failure of growth, followed by death of squabs, on a diet of "white" bread and calcium phosphate (A33, A37, and A38). When the "white" bread is further supplemented by casein and a preparation containing antineuritic vitamine, normal growth and development results. Squabs B70, 72, 811, 833 reached nearly maximum normal weight at the age of about 30 days. Sciatic nerves of A33, A37, and A38 exhibit myelin degeneration.

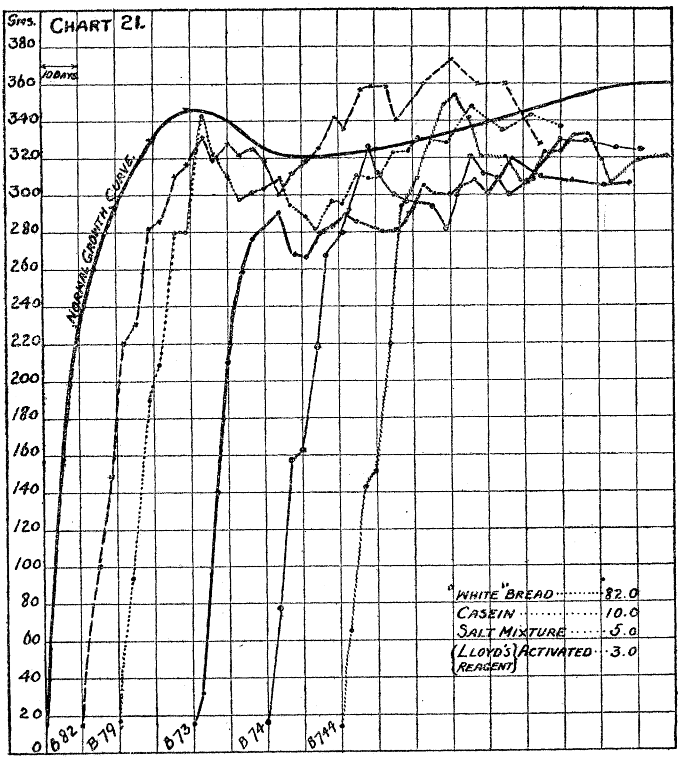

CHART 21.—Shows satisfactory growth of squabs when the "white" bread is supplemented by protein of proper composition, inorganic salts, and antineuritic vitamine. In this experiment the amount of the latter food accessory is twice as large as in the experiments illustrated by chart 20.

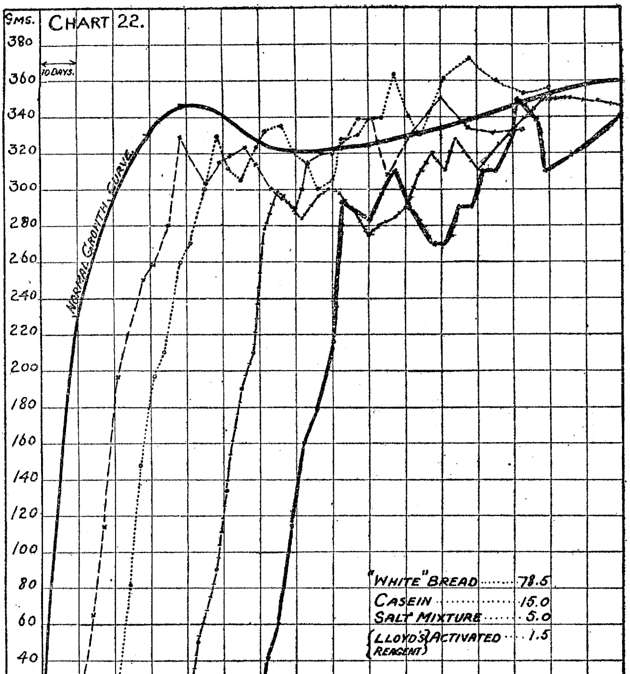

CHART 22.—Growth of squabs. The diet used in this experiment must be considered as physiologically complete. The "white" bread evidently contains sufficient fat-soluble vitamine (derived from evaporated milk) to render this ration adequate for growth.

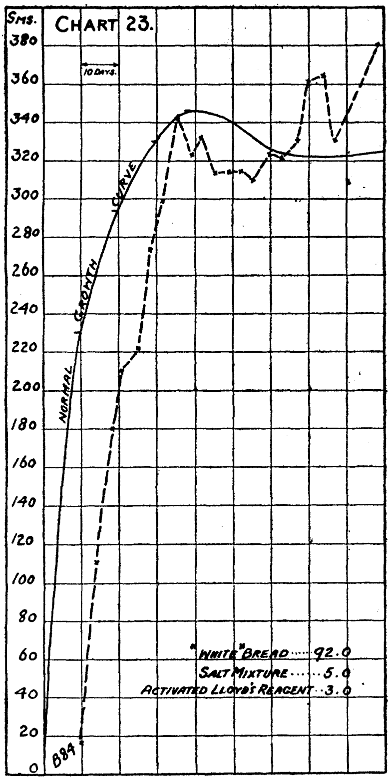

CHART 23.—Shows good growth of a squab on a diet of "white bread," which was supplemented by inorganic salts and antineuritic vitamine. Evidently the "white bread" used in this investigation was prepared with sufficient evaporated milk to correct the deficiency of the highly milled flour in fat-soluble vitamine and protein of proper composition.

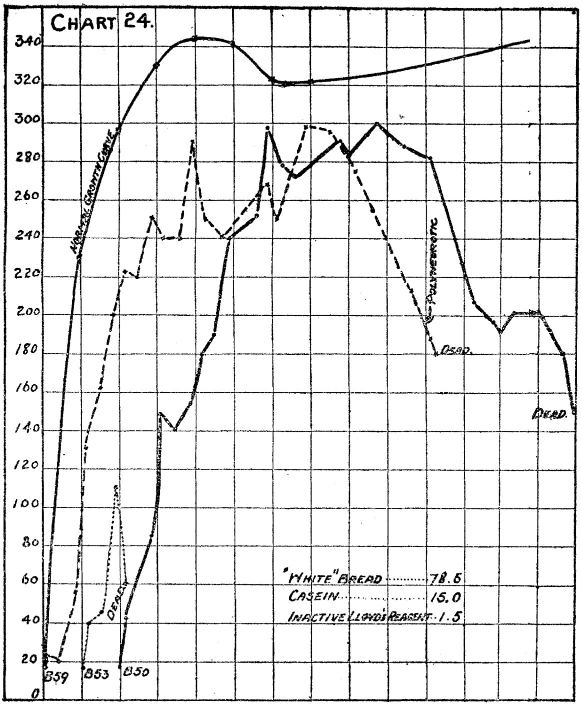

CHART 24.—Shows subnormal growth of squabs on a diet which is deficient in inorganic salts and antineuritic vitamine. The inactive Lloyd's reagent which was added to the diet had not been treated with autolyzed yeast and therefore did not contain the antineuritic substance. Both birds developed polyneuritic symptoms shortly before death.

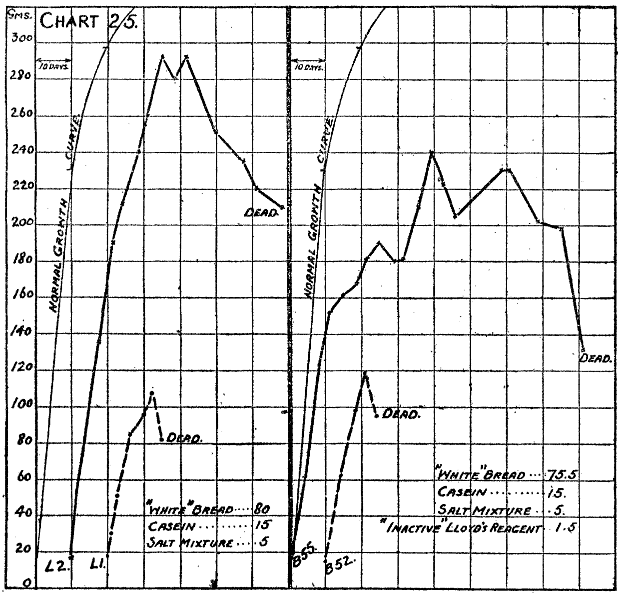

CHART 25.—Shows subnormal growth of squabs, followed by polyneuritis and death, when the "white" bread is supplemented by casein and a salt mixture (L2 and L1). The addition of "inactive" Lloyd's reagent, which has not been treated with autolyzed yeast, does not alter the result (B55 and B52).

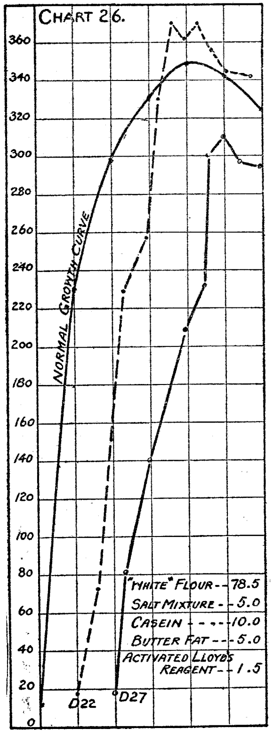

CHART 26.—Shows that squabs grow normally when the "white" flour is supplemented by inorganic salts, protein of proper composition, fat soluble vitamine, and antineuritic vitamine.

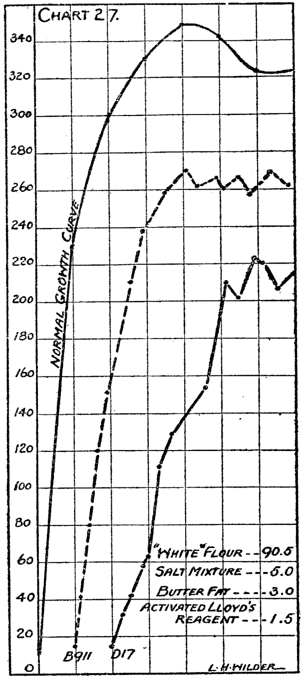

CHART 27.—Illustrates subnormal growth of squabs on a diet which is deficient in protein of proper composition. Compare with charts 28 and 26.

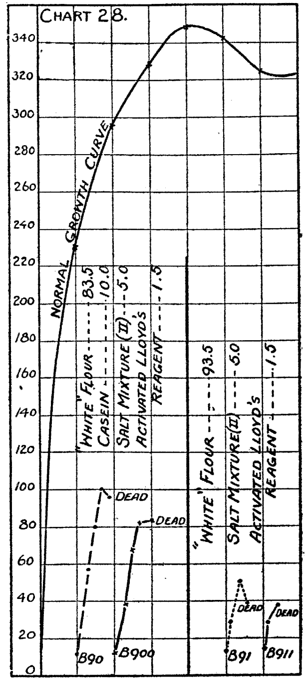

CHART 28.—Growth of squabs on diets deficient in fat soluble vitamine (B90 and B900) or fat soluble vitamine and protein of proper composition. (B91 and B911).

CHART 29 : WEIGHT CURVE OF PIG IV^B.

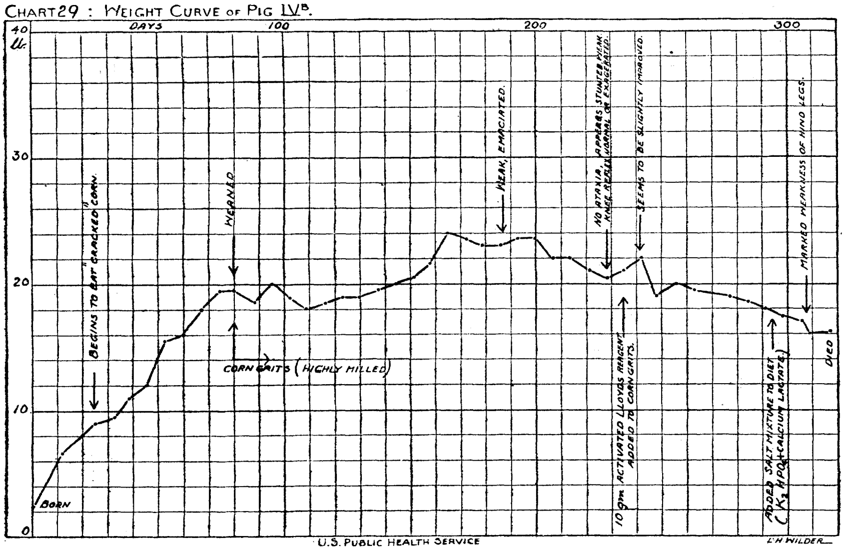

CHART 29.—Illustrates the failure of growth of young hogs on a diet of "highly milled" corn grits. This food was obtained from a roller mill and represents the endosperm of the corn kernel. The animal was born of a hog which had been raised in the laboratory on a diet of cracked corn, wheat straw, and tap water. On the corn grits the animal did not gain more than a few pounds during nine months, in spite of the addition of a supplementary salt mixture and antineuritic vitamine. The animal finally died. The necropsy revealed the following abnormalities: Emphysema of lungs, chronic gastritis, small injected areas in small intestine, chronic passive congestion of liver, congestion of spleen, no scorbutic changes. Sciatic shows marked myelin degeneration. Another pig of the same litter showed a similar growth curve on a diet of corn grits. Here also correction of the salt content and antineuritic vitamine of the diet did not prevent death. Necropsy findings were the same as in Pig IVB.

CHART 30: – WEIGHT CURVE OF PIG II ON DIET OF CORN OIL CAKE, FOLLOWED BY WHOLE CORN.

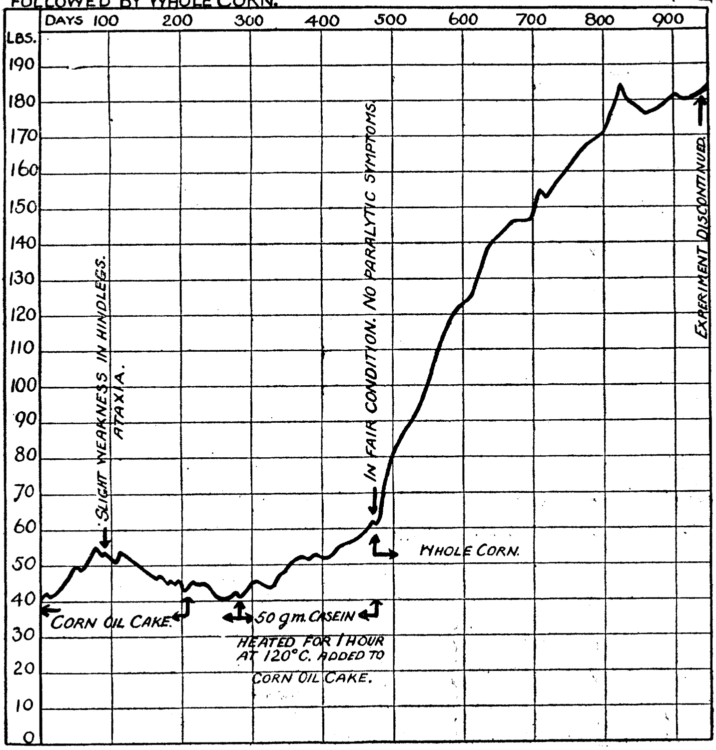

CHART 30.—Illustrates failure of growth of a hog fed on corn oil cake. This product is obtained commercially on a large scale by pressing out the oil from the corn embryo. As soon as this diet was changed to whole corn a rapid increase in the rate of growth followed. This animal reached nearly full size and was in excellent condition at the end of the experiment. Compare this chart with chart 29, where "highly milled" corn grits was fed.